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## Nanostructured materials with unique catalytic properties for renewable energy technologies

The preparation of nano scale materials is one of the most exciting areas of modern science and is at the forefront of the quest for a sustainable future. The field of nanotechnology has generated a great deal of interest primarily because on this size scale numerous new and potentially useful properties have been observed. These size dependent properties include melting point, specific heat, surface reactivities, catalytic, magnetic and optical properties. In particular, the author's group is working on new synthetic methods to control the size, shape and composition of nano scale materials and applying them in systems integral to alternative energy technologies, pharmaceuticals, biomass upgrading, batteries, petrochemicals and environmental cleanup. Recently, the author's research group has developed techniques to produce a number of new nano scale materials that have demonstrated unique catalytic activities through controlled faceting as well as novel intercalation strategies that impart robustness. Here, an overview of the recent highlights regarding these materials and their application in catalytic applications will be presented.



Figure: ZnO nanoflower and Au icosahedra

#### **Recent Publications**

- Feng Lin, Bogdan E Cojocaru, Luke S Williams, Christopher A Cadigan, Chixia Tian, Maria Nicoleta Grecu, Huolin L Xin, Shubham Vyas, Vasile I Parvulescu and Ryan M Richards (2017) Intermediate selectivity in the oxidation of phenols using plasmonic Au/ZnO photocatalysts. Nanoscale 27:9359-9364.
- 2. Amy E Settle, Laura Berstis, Nicholas A Rorrer, Yuriy Roman-Leshkóv, Gregg T Beckham, Ryan M Richards and Derek R Vardon (2017) Heterogeneous Diels-Alder-catalysis for biomass-derived aromatic compounds. Green Chemistry 19:3468-3492.
- Mengze Xu, Calvin Mukurakate, Kristiina Iisa, Sridhar Budhi, Malcolm Davidson, David J Robichaud, Mark R Nimlos, Brian G Trewyn and Ryan M Richards (2017) Deactivation of multi-layered MFI nanosheet zeolite during upgrading of biomass pyrolysis vapors. ACS Sustainable Chemistry & Engineering 5:5477-5484.
- 4. Samuel H Gage, Brian G Trewyn, Cristian V Ciobanu, Svitlana Pylypenko and Ryan M Richards (2016) Synthetic advancements and catalytic applications of nickel nitride. Catalysis Science and Technology 6: 4059-4076.

### **Biography**

Ryan M Richards is a Professor of Chemistry and Associate Vice President for Research at the Colorado School of Mines and holds a joint appointment at the National Renewable Energy Laboratory both in Golden, Colorado USA. He has completed his BS at Michigan State University, MS at Central Michigan University and PhD at Kansas State University. During his PhD studies, he was a Visiting Scientist at the Boreskov Institute of Catalysis in Novosibirsk, Russia. From 2000-2002, he was Max Planck Fellow at the MPI Kohlenforschung in Muelheim, Germany. In 2002, he joined Jacobs University Bremen where he was promoted to Associate Professor before moving to Mines in 2007. He has published more than 140 papers, 7 patents and has served as Editor/Co-editor of three nano science books. He has received numerous awards throughout his career including being selected as a Fellow of the American Chemical Society and 2016 ACS Colorado Section Research Award.

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